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Distilling managerial insights and lessons from AI projects at Singapore's Changi Airport (Part 2)

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By Steve Lee and Steven Miller

Since 2017, Changi Airport group (CAG) has initiated a host of pilot projects that use connective and intelligent technologies to enable its move towards digital transformation and SMART Airport Vision. This has resulted in a first wave of deployment of AI and Machine Learning-enabled applications across various functions that can better sense, analyse, predict, and interact with people.

In a companion article, *AI Gets Real: Learnings from Changi Airport Group*,[1] we have described our experience in using these technologies to improve operational efficiency by predicting fight arrival times more accurately, advance airport safety by identifying dangerous left luggage at the airport and detecting Foreign Object Debris on the runways, and enhance customer service through the deployment of chatbots.

In this article, we elaborate on the lessons learned and managerial insights identified in our learning journey based on the examples described in our companion article, and also based on additional AI projects that are in the process of being implemented and deployed across CAG. We believe these lessons learned should also be applicable to the management of other organisations that are increasingly using AI and connected technologies to execute their digital transformation plans.

From an organisational perspective, CAG is intentionally working on developing internal capability to analyse and solve cross-functional problems faster, as well as better. We are developing a new approach to working across units, and collaborating with our external vendors and consultants. We are also working on how to better systematise and coordinate how we collectively experiment, learn, train and supervise in the context of more agile cross-functional coordination. We are building a group of technology and data science experts internally, and also working with our business partners and vendors to help accelerate our efforts to upskill our people and to deploy AI more widely and deeply. We are supporting this with changes to our business architecture as well as with enhancements to our technology architecture and infrastructure.

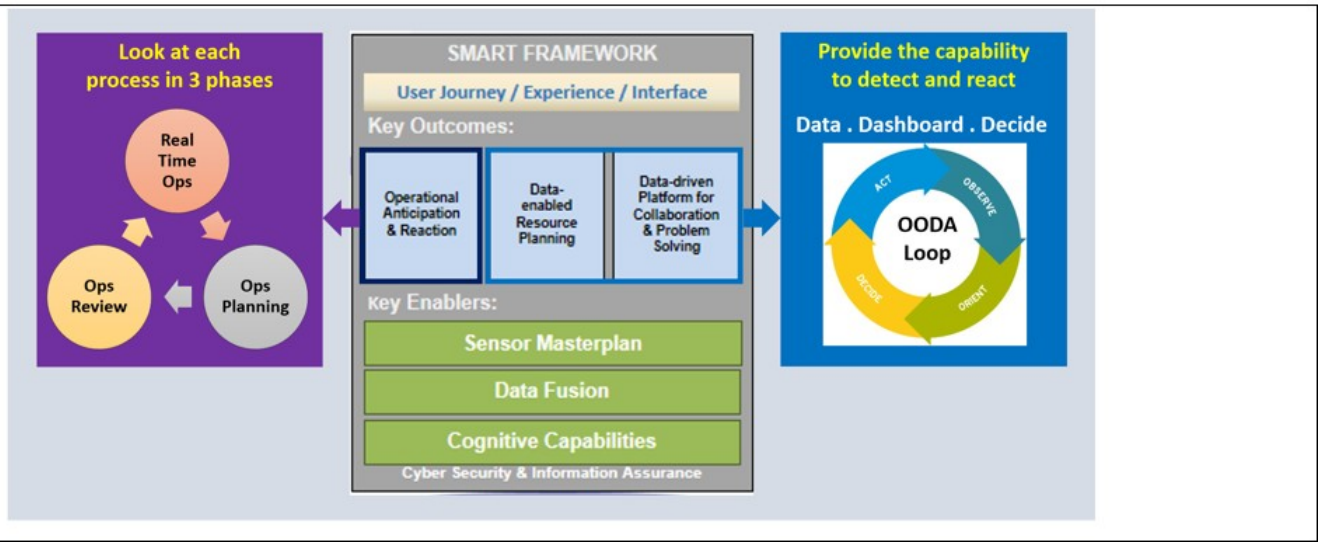
Here, we share six managerial insights that have emerged from Changi Airport's learning journey with our AI projects.

See part 1 on AI gets real at Singapore's Changi Airport. See also AI: Augmentation, more so than automation.

The importance of a conceptual roadmap for guiding our growing portfolio of AI projects

We found it very helpful to create a clear, simple visual representation to convey the big picture and strategic purpose for growing our portfolio of AI projects. The visual representation for our operations-focused projects is shown in *Figure 1*. This image has made it easier for our cross-functional teams to communicate about which type of key outcome they are targeting for capability enhancement, and also the level of key enabler they are contributing to and/or making use of. It has, in addition, helped our cross-functional teams clarify where and how the project fits into the overall management cycle, e.g., planning, review and assessment, or real-time response, and also what aspects of the observe-orient-decide-act (OODA) loop the effort contributes to.

Figure 1: Changi Airport's conceptual roadmap for realising the SMART Airport Vision



Rethinking our strategies for out-sourcing, in-sourcing and co-sourcing to move with greater agility and speed

We want to move faster in our efforts to implement our SMART Airport Vision. This requires us to move faster in our efforts to expand and enhance our sensor infrastructure, our data management and data fusion capabilities, and our cognitive system capabilities (analytics, AI, Machine Learning). Changi Airport faces the same constraints that any established organisation delivering physical-world services as it fully embraces digital transformation and more deeply integrates the physical and digital aspects of its business. Each of these constraints has strong implications for our technology capability sourcing approach:

1. While we have a strong IT organisation that has designed and implemented many IT support systems over the years, we lack specific skills and expertise in the relevant new technology areas. This gap is most notable in the various specialised aspects of AI and Machine Learning, in the related sensor technologies, and in new and more rapid approaches to IT infrastructure and application deployment.

2. There is a shortage of capable and deeply-skilled talent to hire in these new technology areas.

3. Because of the imperative to more deeply integrate all of the physical aspects of the business with digital, and because of a growing number of new 'all digital/native digital' internal initiatives, we now have to design, guide, provide for, and/or support a much wider range of IT systems than was the case previously. This has implications for having the requisite skills and expertise in place.

4. We want to protect our proprietary business domain knowledge pertaining to airports and airport operations, as that is a very important source of competitive advantage.

5. While we have previously done cross-functional projects, the cross-functional coupling and coordination is becoming even more important as we embrace digital transformation, and correspondingly, the nature of the cross-functional interactions is getting deeper and more complex.

6. The imperative to move at speed to try new things, to experiment, and to change in ways that lead to successful business innovation is unrelenting. In parallel, counterbalancing forces for stricter risk management due to cybersecurity concerns, data privacy concerns, and other regulatory and risk factors that directly impact our digital transformation efforts are also growing in an unrelenting manner.

7. Not only are the technologies and tools related to AI applications rapidly evolving, but the overall business, competitive, societal and political landscapes too are shifting, inducing macro-environment uncertainties that filter down to the level of our AI and related technology project objectives while work is underway.

The first three items in the list above would suggest a move towards more out-sourcing and co-sourcing. The fourth item, protection of propriety knowledge, strongly pushes in the opposite direction of more in-sourcing. And the last three items on the list show that, whatever path we take with respect to our proportions of out-sourcing, in-sourcing and co-sourcing, it is a more challenging environment than we have ever encountered, which calls for new ways of working within our organisation, as well as with our external providers of technology products and services.

Despite our prior (and strong) experience base for managing and executing IT projects for business improvement and transformation efforts, nothing can be taken for granted as essentially each new AI project and related projects we now encounter are taking us into new territory. This has important implications for our changing requirements of skills and expertise, and for how we organise and execute our efforts.

As an organisation, we have had to substantially rethink and re-orient our previously existing approaches to technology capability sourcing in a way that will support our portfolio of AI projects and the SMART Airport Vision. We see the composition and trajectory of our technology capability sourcing as something that will keep changing over the near-, mid- and long-term, as we continue to dynamically alter our proportions across the options of in-sourcing, out-sourcing and co-sourcing.

The criticality of our internal knowledge of our specific business domain and business needs

For these new AI applications to be effective, they have to be deeply integrated into the specifics of our airport business setting, and be very specifically tuned to meet our particular business needs. Our internal Changi Airport team, which includes both the business unit side and the IT side, has to play a key role in every AI project we undertake in order to bridge the substantial knowledge gaps between the general purpose capabilities of commercially- available AI methods and tools, and our very specific airport setting, data sources, and needs. Even when we work with external vendors that focus on the aviation industry and airport domains, there are still substantial knowledge and requirement gaps that we need to fill.

For organisations that have not already been through several of these AI projects, it would be easy to vastly underestimate the amount of effort that your business owners, domain specialists and data specialists (including both the business users of the data and the IT owners of the data) must put into working with those who are building, testing and refining the analytics/AI/Machine Learning models.

Indeed, if you internally replicate similar applications one after the other, there will be a learning curve, and the planning and implementation time for subsequent efforts would benefit from experience and prior preparation and would be shorter. But each new type of project—new objectives, new setting, new data sources—is very time-intensive, not only for the model builders, but also for all of those who have various types of domain expertise and data expertise required to support the effort. This leads us to the next point about the importance of iteration.

The criticality of iteration for addressing key management issues and also improving system and process performance

As we pursue this new generation of capability-enhancing projects involving sensors, data fusion, analytics, and AI, and orchestrate these capabilities into various levels of task automation and human decision support tools, the basic business questions are ever present, and must (as always) be answered clearly:

- What is the problem we are trying to solve?
- What will improve, and who will benefit?
- What actions will this enable us to take, and how will those actions lead to improvement?
- What are the performance versus cost trade-offs and choices?
- What are the overall cost versus benefit trade-offs and choices?

These basic types of questions do not go away just because we are embarking on an exciting, new AI project innovation initiative, or deploying a 'hot' technology for the first time in our organisation, or perhaps even pushing the frontier and attempting what would be the first-of-a-kind implementation relative to what others have done worldwide. In fact, these basic management questions become even more important given the complexity and resource intensity of these new types of projects.

Changi Airport has always had to answer these basic managerial questions with every project approval and capital investment we have made over the decades. In this sense, we are very familiar with how to go about asking these types of questions, and knowing when we have a credible answer. What is new, however, is operating in the current and rapidly evolving environment where we have limited and/or uncertain information about applying these new technologies into our system and processes. As such, there is still a high degree of uncertainty about performance, costs, benefits, trade-offs, and resource requirements.[2]

We are rapidly gaining experience within these new technologies through our first wave of pilot deployments. Even so, relatively speaking, we still only have sparse amounts of supporting empirical evidence and experience with addressing these questions in the specific context of these new types of AI applications, especially when we consider moving from smaller-scale pilot applications to larger-scale production deployments. We must mobilise quickly to acquire the knowledge, expertise and experience to address these types of basic managerial questions. Being able to address these questions in our very specific domain setting must be one of our core competencies. Our conceptual roadmap, sourcing strategies and internal knowledge (points mentioned above) all help us to develop and strengthen this necessary core competency.

We can only arrive at the necessary understanding and answers to these key management questions in an iterative fashion. While we always need a disciplined approach to make sure we address these key management issues, we must also be highly tolerant of uncertainty, especially in the earlier stages of our journey with AI applications and the more general digital transformation.

We have also come to see how learning through progressive iteration is critically important to our project efforts to design, deploy, test, refine and scale AI applications. We now have a clearer understanding of the iteration cycle for each of our AI modelling and prediction projects:

- Understanding the factors that influence the variable we are trying to predict.
- Creating an adequate and clean data set that can be used to create the models for making the prediction.
- Successive fine-grained model iteration based on feedback from, (i) building, training, testing and validating the prediction model, and (ii) updating, refining and re-training the prediction model.
- Simultaneous staging and scaling of the physical infrastructure and data management support required for each of the steps above.
- Coupling the outputs of our AI analysis and prediction efforts with relevant downstream processes in order to make use of the prediction in a way that leads to tangible value creation or productivity improvement.

We have learned how important it is to take a phased approach to developing and validating AI-based prediction systems. We started with easier use cases, and demonstrated that it was possible to make progress, even if our prediction accuracy was not at the levels we knew we eventually desired. We continued to expand by taking on additional circumstances (or use cases) which are progressively harder to predict and which took us towards accuracy levels closer to our desired target. The point is, we did not start with the most difficult situations. We found those situations that were easier to work on—but even so, the initial efforts were difficult. The key is to be able to show progress and success, and to continue to iterate. Gradually and steadily, the increasingly difficult aspects of analytics and prediction will be addressed. In parallel, through successive iteration, complex issues related to infrastructure, data management and downstream process coupling will evolve towards what is required.

The availability of new data sources, including open data sources, is a game changer

We have three main insights to share about data sources. First, there is more sensor data available in recent years owing to the improvements in existing types of sensors, the appearance of new types of sensors, and dramatic improvements in analytic methods for processing, interpreting and using sensor information due to developments in AI and Machine Learning.

Second, we came to realise that we were already sitting on some types of sensor information that we were not using to its fullest potential. In some cases, we had not connected a particular type of sensor to our network, and therefore, we could not take advantage of everything that follows from having information that can be accessed via our internal network (in a highly secure way). We also had many examples of familiar and seemingly conventional data collection that we were already very familiar with, and were regularly used for reporting, but did not think of this information as a 'sensor' in the way that one thinks of the output of a video camera or a vibration sensor as sensor data. We came to appreciate that there are many types of sensors and many forms of sensor data.

The third point is that there is a growing number of openly-available sources of data that can be of great use to us. One example that is very particular to aviation and flight tracking is the Automatic Dependent Surveillance Broadcast (ADS-B) system, which is a global means of getting update information on the position of an aircraft using information transmitted between the aircraft and satellites. It is a different means of tracking aircraft than using ground-based radar, and it is more easily accessible, and a lot less expensive.

The key point is that in every industry and in every problem setting, one needs to be on the lookout for new sources of data that can be used for analytics, prediction and decision-making. And one needs to pay special attention to the growing availability of openly available data sources. There are some situations where an openly available source of data could be accessed to provide adequate data quality and coverage at substantially less cost.

The power of data fusion

While every point highlighted above is important, this final point deserves special mention in Changi's journey with AI applications and overall digital transformation. Data fusion efforts are especially important and especially strategic to realising value from the AI applications.

The basis of connective technologies is data, and the business outcomes of these technology-enabled programmes closely depends on the data itself, and on the ability to integrate multiple data sources to produce more consistent, accurate and useful information. AI and Machine Learning projects require good data, and a lot of it. The data fusion effort involves recognising what data is needed, what is available, and how to put that available data together for meaningful use. It is a challenging and time-intensive effort because it requires going down to the deepest roots of business practices and processes, and even clarifying and questioning the raison d'être for existing business practices. Yet this investigative effort is necessary so that the right data can be collected through a combination of integrating existing sources and providing new data sources from new sensor applications, and feeding all of this into the analytics and prediction engines.

With respect to customer understanding and engagement, data fusion helps us to move toward the ideal of a full 360- degree view of our airport customers based on multiple types of interactions. For our airport operations, data fusion enables us to move toward our vision of providing the various operations units with a common view and understanding of the situation at the airport with respect to people flows and queues, airplanes and airplane support equipment positions and status, and resource needs versus resource availability for every type of customer facing and operations support task that we must provide. Adding more types of data provides different dimensions of visibility, and hence data fusion efforts can lead to a multiplier effect for deriving useful insights for new opportunities for value generation and for productivity improvement.

Data fusion efforts are hard work. They are complex. They involve addressing many types of technical and organisational challenges. Even so, if the management team is clear on the key management issues, data fusion efforts will result in great benefits for all stakeholders: customers, internal stakeholders, and service provider partners.

We believe the lessons and insights we have experienced at CAG over the past few years can provide useful guidance to other organisations that, like us, were not 'born' as fully-digitised companies, but nonetheless have embarked, or are planning to embark, on their digital transformation efforts.

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References

1Steve Lee and Steven M. Miller, "AI Gets Real at Singapore's Changi Airport," Asian Management Insights, Vol 6, Issue 1 (May 2019), Singapore Management University.

2 It is worth noting that evaluating the business impacts of AI is actually not a new situation. Many corporations have previously had the need to evaluate practical project and investment decisions in face of uncertainty about performance, costs, benefits and trade-offs, especially as companies consider larger scale efforts. Industry has faced this situation before with earlier generations and waves of computer-enhanced automation. For example, see the classic article by Robert S. Kaplan, "Must CIM be justified by faith alone," Harvard Business Review, March 1986. Also, Tom Davenport's recent book, "The AI Advantage: How to Put the Artificial Intelligence Revolution to Work," 2018, MIT Press, discusses how companies have been learning to evaluate the business benefits and costs of AI development and deployment projects as they have been experimenting and piloting applications over the past several years.